

## Argonne and partners help biorefineries compete with oil refineries

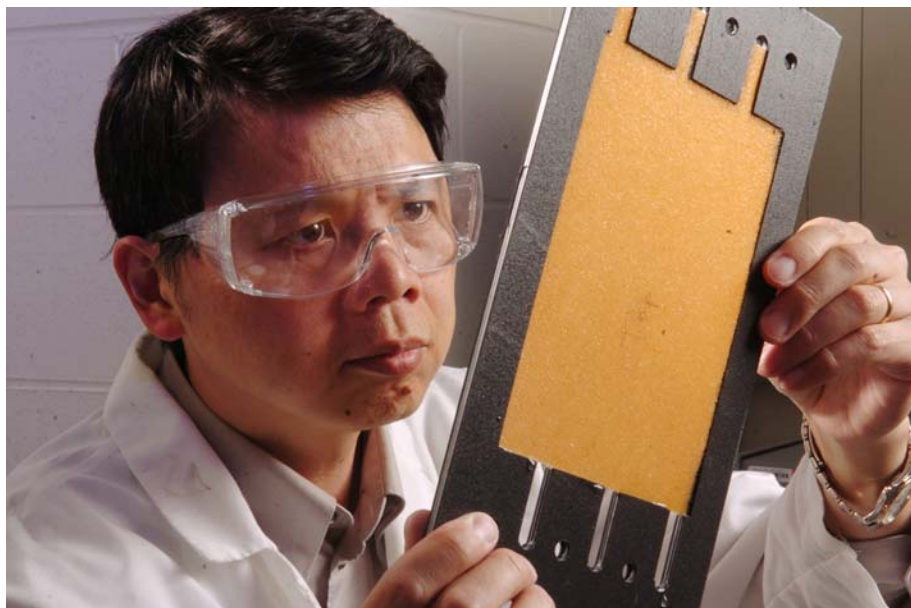
Argonne researchers are partnering with industry and other national laboratories to develop biorefineries that compete economically with oil refineries.

One of the world's most touted bioproducts is ethanol. Its production is increasing by 20 percent annually, and last year the nation produced 4 billion gallons.

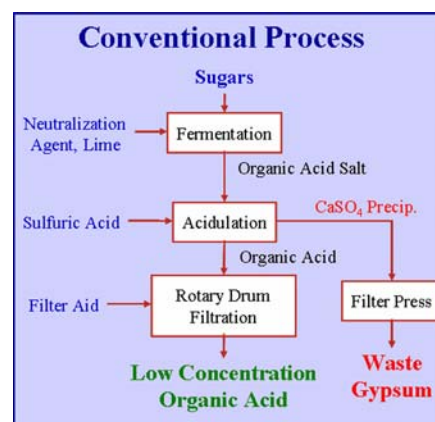
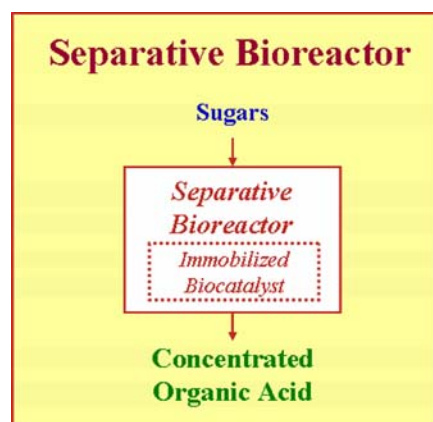
"Making ethanol is already half as cheap as making gasoline," explained Seth Snyder, a biochemical engineer and the leader of the Chemical and Biotechnology Section in Argonne's Energy Systems Division. "Researchers at Argonne and around the nation are investigating ways to create new bioproducts that can compete with petrochemicals on cost and performance."

Argonne is one of five U.S. Department of Energy (DOE) laboratories working to replace 30 percent of today's motor fuel with alternative biofuels by 2030. Called the National Bioenergy Center, the team includes Idaho, Oak Ridge and Pacific Northwest national laboratories and the National Renewable Energy Laboratory.

"Researchers and industry see developing alternative processes to replace the country's reliance on foreign oil as filling a national need," he said. "It is not just the price of gas we are concerned about, but the overall costs of petroleum products.. As oil prices rise, so do all petroleum-based



**RESIN WAFER** – Argonne's Yupo Lin inspects the resin wafer in a gasket before loading it into the bioreactor.



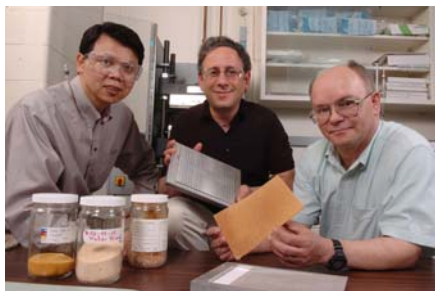
**SIMPLER TECHNOLOGY** – The diagrams above compare the one-step process of Argonne's separative bioreactor (left) with the multi-step conventional process.

products, including paint, plastic and carpets."

Products traditionally made from oil can be made from plants and trees, but the processes need to be developed to make their products

price-competitive with petroleum-based products.

Argonne is working with Archer Daniels Midland Company (ADM) to optimize a separative bioreactor,



**BIOREACTOR TEAM** – This team developed a one-step separative bioreactor that may cut the nation's dependence on oil as a source for valuable chemicals. From left, Yupo Lin, Seth Snyder and Mike Henry.

developed by Snyder's group, that converts sugar from corn into chemicals. *R&D* magazine named the technology one of this year's top R&D products. This research is supported jointly by the U.S. Dept. of Energy's Office of the Biomass Program and ADM.

The Argonne-ADM effort currently focuses on demonstrating the fermentation of gluconic acid on a commercial scale. "Gluconic acid is one of many bioproducts from biomass," Snyder said. "We have to work through the processes one by one to build up an inventory to compete with petrochemical processing. We chose to start with gluconic acid because we are familiar with its processes."

Gluconic acid is produced by fermenting glucose, a type of sugar. This reaction has been known for more than 100 years. During fermentation, gluconic acid builds up until its acidity blocks the fermentation enzyme. The acidity can be chemically neutralized, but the extra treatment raises costs and generates waste.

Argonne's separative bioreactor uses a process called "electrodeionization" to overcome this problem without the need for additional chemical treatments. Electrodeionization uses small amounts of electricity and Argonne's resin wafer stack to remove gluconic acid from the solution as it is produced. Yupo J. Lin, the chemical engineer leading this project, says that "with the acid removed, the enzyme will continue to convert glucose to gluconic acid."

In a related project, Argonne is partnering with BP Chemicals to produce acetic acid by fermentation of biomass. The U.S. currently uses about 5 billion pounds per year of acetic acid, to make everything from plastics used in water bottles to paints. In research supported by DOE's Industrial Technologies Program and BP, Argonne is developing technology to produce acetic acid from a kind of biogas. The current technology requires expensive natural gas.

Argonne believes that a similar biogas strategy could also be used to produce ethanol directly. In parallel projects, Argonne is developing microorganisms and chemical catalysts to convert the gas to ethanol. At the same time, Argonne is working on new ways to recover the ethanol from the fermentation broth.

"But in the long run, we'll have to move beyond corn as a feedstock," Snyder said, "if bioprocessing is to compete with petroprocessing." Possible new biofeedstocks include forest products, agricultural fodder—such as corn cobs and husks—and fast-growing grasses.

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Argonne researchers are using their expertise in engineering trees for environmental cleanup to develop more possible sources for bioprocessing. Argonne's Cristina Negri is expanding her study of poplar trees to determine if they can be engineered to grow in dry areas. "Trees and plants that can grow in marginal areas will add to the biofeedstock without using land that is better suited to growing food crops," Snyder explained.

Argonne's effort cuts across scientific disciplines. Snyder's group plans to work with Argonne computer scientists to explore how genomics and systems biology can improve bioprocesses and the crops that will be used to produce bioenergy and bioproducts.

The buzz about ethanol has escalated this year, along with the price of gasoline, but Argonne has been studying ethanol for decades. The laboratory served as the cold weather test site for ethanol-fueled vehicles in the 1980s and 1990s. Environmental engineers and economists are determining the full-cycle energy costs of ethanol and many other alternative fuels and technologies. DOE uses GREET, a life-cycle analysis program developed by Argonne's Michael Wang, to help guide decisions in ethanol research.



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